SESA Re-Filing of Smart Inverter Setting Recommendations
Docket NEPR-MI-2019-0009

April 25th, 2025

The Solar and Energy Storage Association of Puerto Rico (SESA) respectfully re-submits the same recommendations originally filed on February 10, 2025. Since that filing, real-world operational experience has confirmed the negative impacts on solar customers we originally identified. Under the current mandated smart inverter settings, many solar customers are unable to operate their systems even during grid conditions that are normal for Puerto Rico's distribution system, leading to economic harm, reduced clean energy production, and missed opportunities to strengthen the electric grid.

We are submitting herein a full track-changes version of the proposed settings, showing exactly what we request to be approved. Our proposal would allow distributed energy resources (DERs) to remain energized during grid conditions which are normal on the island, and automatically safely disconnect during abnormal events, aligning Puerto Rico's requirements with the intent and flexibility provided by IEEE 1547-2018. The IEEE standard does not define a fixed "normal" but rather provides a range of allowable settings, with the expectation that local regulators will tailor those settings to reflect what is considered normal and abnormal for their specific grid.

Importantly, we have engaged in multiple collaborative discussions with LUMA's technical staff to work through these issues. While progress has been made, and we are encouraged by the open dialogue, a complete agreement on all requested changes has not yet been reached as of today. Therefore, we are proceeding with this formal re-filing, informed by major inverter manufacturers operational in Puerto Rico to be advisable, safe, and mutually beneficial both to providing maximal grid support as well as minimizing negative customer impacts.

SESA's proposed settings would:

- Ensure DERs operate fully during grid conditions that are typical for Puerto Rico's distribution system;
- Provide critical voltage and frequency support through smart inverter functions like Volt-Var;
- Disconnect DERs only when truly abnormal grid conditions are present, improving grid stability for all.

We continue to recommend and strongly request that Volt-Watt activation not be mandated at this time, and that consideration of any widespread adoption of Volt-Watt be delayed for at least another year (ie through at least June of 2026), as a general requirement for Volt-Watt activation would definitely cause significant more curtailment for many customers, and there is currently no financial mechanism in place to compensate customers for lost revenue associated with lost solar power output. Activation of the Volt-Watt setting would trigger problems unsolvable in the short term, both legal as well as Constitutional, as imposed changes resulting in negative financial harm would constitute a complicated and unjust "taking".

We do however acknowledge the potential value of observing the impact of different specific smart inverters settings, if conducted in a way that's mutually agreed to by LUMA and any companies participating in the pilot, and consented to by customers that would be participating on a voluntary basis.

In summary, based on customer experience and collaborative technical dialogue to date, we respectfully request that the Energy Bureau approve the attached changes to the Smart Inverter technical requirements, in the interest of consumer protection, grid reliability, and Puerto Rico's energy resilience.

Thank you for consideration of these important comments.

Sincerely,

PJ Wilson
Executive Director
SESA Puerto Rico

Attached:

Attachment 1 – Proposed New Settings, showing "track changes" and explanatory "comments"

Attachment 2 – Proposed New Settings, showing "comments" (without "track changes")

Attachment 3 – Full, Clean, Proposed New Smart Inverter Settings for Puerto Rico

Attachment 1 – Proposed New Settings, showing "track changes" and explanatory "comments"

Table of Contents

Commented [A1]: Original Table of Contents was missing a reference to the Enter Service Settings section. Also, the titles of the sections and subsections are updated to reflect the names from the original filing. Also included is a new section for unintentionally excluded Frequency Droop settings.

List of Tables

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Commented [A3]: Table 2-7 header is revised to change "ACTIVATED" to "DEACTIVATED". See rationale provided in Section 2.5

List of Figures

1. Required Smart Inverter Functions

Smart Inverters must be (a) UL 1741 SB listed, (b) set to the default setting provided in this document, and (c) perform the default functions, provided in this document, "Smart Inverter Settings Sheets".

Customers must comply with the requirements set forth in this "Smart Inverter Settings Sheets" except where alternative site-specific Smart Invert settings and function statuses are defined in the interconnection agreement as a result of a detailed interconnection study. Any alternative settings and function statuses defined in the interconnection agreement will take precedence and supersede the default settings and function statuses provided in this document. Notwithstanding the following provisions of this "Smart Inverter Settings Sheets", customer's Smart Inverter(s) shall conform with the requirements and functions required pursuant to interconnection agreement.

1.1. Communication Requirements

Table 1-1~~Table 1-1~~~~Table 1-1~~~~Table 1-1~~ lists the eligible communication protocols for Smart Inverters connected to the distribution system. Smart Inverters connecting to the distribution system shall be capable of supporting at least one of these protocols.

Table 1-1- List of eligible communication protocols

Protocol	Transport	Physical Interface/Layer
IEEE 2030.5 (SEP 2.0)	TCP/IP	Ethernet
IEEE 1815 (DNP3)	TCP/IP	Ethernet
SunSpec Modbus	TCP/IP	Ethernet
	N/A	RS-485

1.2. Smart Inverter Functions and Control Modes

Table 1-1~~Table 1-1~~~~Table 1-1~~~~Table 1-11-2~~ lists functions and control modes that must be supported by Smart Inverters as well as the default status of each function and control mode.

Commented [A4]: Corrects improper table reference (Table 1-1 to Table 1-2)

Table 1-2- Smart Inverter Control Modes

Applicable to Retail Customers Interconnected			
Function/ Control Mode of Operation	**Required/Optional**	**Description**	**Default Activation Status**
Anti-Islanding	Required	Refers to the ability to detect loss of utility source and cease to energize	Activated
Constant power factor	Required	Refers to Power Factor set to a fixed value.	Deactivated
Active Power~~+~~ – Reactive Power	Required	Refers to the control of real power output as a function of reactive power	Deactivated
Constant Reactive Power	Required	Refers to Reactive Power set to a fixed value	Deactivated
Voltage Ride through	Required	Refers to the ability of Smart Inverter to ride through a certain range of voltages before tripping off	Activated
Frequency Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	Activated
Voltage – Reactive Power (Volt/Var)	Required	Refers to control of reactive power output as a function of voltage	Activated
Voltage – Active Power (Volt/Watt)	Required	Refers to control of real power output as a function of voltage	~~Activated~~Deactivated*
Frequency Droop (Frequency – Watt)	Required	Refers to control of real power as a function of frequency	Activated
Enter Service	Required	Refers to the ability of smart inverters to begin operation with an energized utility source.	Activated
Normal Ramp-up Rates	Optional	Refers to ability to transition between energy output levels over the normal course of operation	Activated, if available
Connect/Reconnect Ramp-up rate	Required	Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power	Activated

*~~Will remain Deactivated for at least 6 months.~~ Not earlier than June 30, 2026~~2025~~, the Energy Bureau will consider approving, through Resolution, the activation of this function after considering: (i) recommendations from LUMA and Working Group regarding system performance, (ii) implementation of adequate reporting and tracking requirements for customer curtailment, and (iii) LUMA has developed an effective plan to manage distribution voltage, that relies on Volt-Watt functionality as a last resort mechanism to temporarily correct voltage issues.

Commented [A5]: Addressed formatting inconsistencies in this row to center the values in the cells.

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Commented [A9]: Correct formatting (left justified) for consistency

Commented [A10]: Postpones until at least June 2026 consideration of Volt-Watt activation.

2. Smart Inverter Function and Control Mode Settings

This section lists the required settings for Smart Inverter functions and control modes.

2.1. Anti-Islanding

Smart Inverters shall detect the unintentional island and trip as specified in Table 2-1.

Table 2-1- Responses to Islanding and Open Phase Conditions - ACTIVATED

Applicable to Retail Customers Interconnected	
Condition	**Maximum Trip Time (s)**
Islanding/Open Phase	2

2.2. Response to Abnormal Voltage

2.2.1. Voltage Trip Settings

Smart Inverters shall meet the abnormal voltage response requirements, as specified in Table 2-2.

Table 2-2- Smart Inverter Response to Abnormal Voltage

Voltage Trip Settings	Default Voltage (pu)	Adjustable Range for Voltage (pu)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Voltage 2 (OV2)	V ≥ 1.2	1.2	0.16	Fixed at 0.16
Over Voltage 1 (OV1)	V ≥ 1.1	1.1 - 1.2	13	1 - 13
Under Voltage 1 (UV1)	V ≤ 0.88	0 - 0.88	21	11 - 50
Under Voltage 2 (UV2)	V ≤ 0.5	0 - 0.5	2	2 - 21

2.2.2. Voltage Ride-Through

Smart Inverters shall meet the Low/High Voltage Ride-Through requirements, as specified in Table 2-3, which match the required response for Abnormal Operating Category III.

Table 2-3- Low/High Voltage Ride-Through Minimum Requirement – ACTIVATED

Voltage Range	Voltage Range (pu)	Operating Mode/Response	Maximum Ride Through Time (s) (design criteria)	Minimum Ride Through Time (s) (Design Criteria)
High Voltage 2	V ≥ 1.2	Cease to Energize	0.16	N/A
High Voltage 1	1.1 < V ≤ 1.2	Momentary Cessation	0.083	12
Near Normal Voltage	0.88 ≤ V ≤ 1.1	Continuous Operation	N/A	Infinite
Low Voltage 1	0.7 ≤ V < 0.88	Mandatory Operation	N/A	20
Low Voltage 2	0.5 ≤ V ≤ 0.7	Mandatory Operation	N/A	10
Low Voltage 3	V ≤ 0.5	Momentary Cessation	0.083	1

Commented [A11]: A space added to address formatting to be consistent.

Commented [A12]: Addresses an symbol error (from less-than-or equal symbol to less-than symbol) in table to make it compliant with IEEE 1547-2018 Table 16.

Commented [A13]: Addresses an symbol error (from less-than-or equal symbol to less-than symbol) in table to make it compliant with IEEE 1547-2018 Table 16.

2.3. Response to Abnormal Frequency

2.3.1. Frequency Trip Settings

Smart Inverters shall meet the abnormal frequency response requirements, as specified in Table 2-4.

Table 2-4- Smart Inverter Response to Abnormal Frequency

Frequency Trip Settings	Default Frequency (Hz)	Adjustable Range for Frequency(Hz)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Frequency 2	f ≥ 62	61.8 - 66	0.16	0.16 - 1000
Over Frequency 1	f ≥ 61.2	61.2 - 66	300	21 - 1000
Under Frequency 1	f ≤ 58.5	50 - 58.8	300	21 - 1000
Under Frequency 2	f ≤ 56.5	50 - 57	0.16	0.16 - 1000

2.3.2. Frequency Ride-Through

Smart Inverters shall meet the Low/High Frequency Ride-Through requirements, as specified in Table 2-5, which match the required response for Abnormal Operating Categories I, II, and III.

Table 2-5- Low/High Frequency Ride-Through Minimum Requirement – ACTIVATED

Frequency Ride-Through Settings	Frequency Range (Hz)	Operating Mode	Minimum Ride Through Time (s)
High Frequency 2	f ~~>~~≥ 62	N/A	N/A
High Frequency 1	61.2 < f ≤ 62	Mandatory Operation	299
Near Normal Frequency	58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite
Low Frequency 1	57 ≤ f < 58.8	Mandatory Operation	299
Low Frequency 2	f ~~<~~≤ 57	N/A	N/A

Commented [A14]: Addresses a symbol error in table to make it compliant with IEEE 1547-2018 table 19 (replace greater-than-or-equal-to symbol with greater-than symbol).

Commented [A15]: Addresses a symbol error in table to make it compliant with IEEE 1547-2018 table 19 (replace less-than-or-equal-to symbol with less-than symbol).

2.4. Voltage-Reactive Power Control Mode Settings

An example Volt-Var characteristic is shown in Figure 2-1~~Figure 2-1~~~~Figure 2-1~~~~Figure 2-1~~. The voltage-reactive power characteristic shall be configured in accordance with the default parameter values specified in Table 2-6~~Table 2-6~~~~Table 2-6~~~~Table 2-6~~.

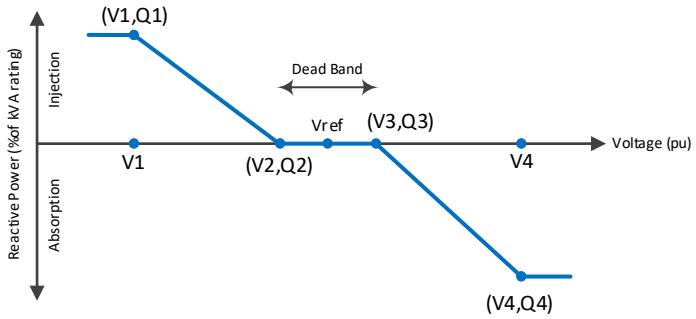

Figure 2-1. Example Volt-Var characteristic

Table 2-6- Volt-Var Settings – ACTIVATED

Volt-Var Parameters	Definitions	Default Values (% of nominal rating)	Allowable Range	
			Minimum	Maximum
Vref	Dead band center	VN	95% VN	105% VN
V2	Dead band lower voltage limit	98% VN	Vref – 3%VN	Vref
Q2	Reactive power injection or absorption at voltage V2	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V3	Dead band upper voltage limit	105% VN	Vref	Vref + 3%VN
Q3	Reactive power injection or absorption at voltage V3	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V1	Voltage at which DER shall inject Q1 reactive power	92% VN	Vref – 18%VN	V2 – 2%VN
Q1(1)	Reactive power injection at voltage V1	44%	0	maximum reactive power capability, injection
V4	Voltage at which DER shall absorb Q4 reactive power	108% VN	V3 + 2%VN	Vref + 18%VN
Q4(1)	Reactive power absorption at voltage V4	44%	maximum reactive power capability, absorption	0
Open loop response time	Time to 90% of the reactive power change in response to the change in voltage	5 sec	1 sec	90 sec

(1) This requires that the Smart Inverter operates with a reactive power priority and generate/absorb reactive power to the ranges specified in this table irrespective of active power production.

2.5. Voltage-Active Power Control Mode Settings

Two examples of these characteristics are shown in Figure 2-2~~Figure 2-2~~~~Figure 2-2~~~~Figure 2-2~~. The characteristic shall be configured in accordance with the default parameter values specified in Table 2-7.

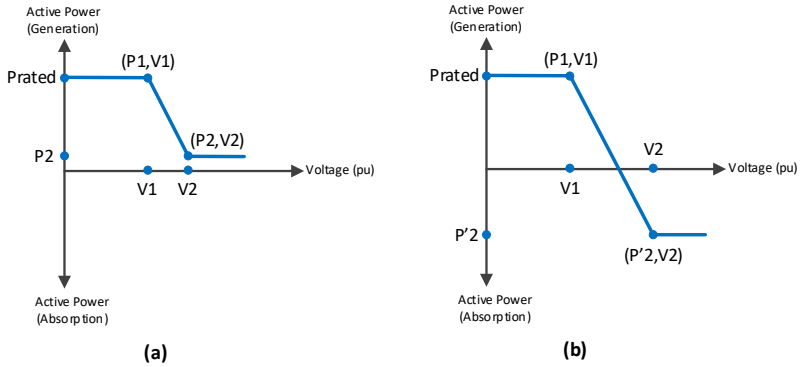

Figure 2-2~~22~~. Example Volt-Watt characteristics

Table 2-7- Volt-Watt Settings –[3] DEACTIVATED

Voltage-active power parameters	Default Settings	Ranges of allowable settings	
		Minimum	Maximum
V1	106% VN	105% VN	109% VN
P1	P_{RATED}	NA	NA
V2	110% VN	V1 + 1% VN	110% VN
P2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{RATED} or P_{MIN}[1]	P_{MIN}	P_{RATED}
P'2 (applicable to DER that can generate and absorb active power)	0	0	P'_{RATED}[2]
Open-loop response time	10 sec	0.5 sec	60 sec

[1] P_{MIN} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.).
[2] P'_{RATED} is the maximum amount of active power that can be absorbed by the DER.
[3] Will remain Deactivated for at least 6 months. Not earlier than June 30, 2025, the Energy Bureau will consider approving through Resolution, the activation of this function after considering: (i) recommendations from LUMA and Working Group regarding system performance, (ii) implementation of adequate reporting and tracking requirements for customer curtailment, and (iii) LUMA has developed an effective plan to manage distribution voltage, that relies on Volt-Watt functionality as a last resort mechanism the temporarily correct voltage issues.

Commented [A16]: Formatting edits for use of space on page 7 keeps all Volt-Watt information on one page without compromising readability.

Commented [A17]: Given that it is not certain Volt-Watt will be required, DEACTIVATED should be the status until such time a PREB Resolution is issued and with a revision of this bulletin.

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Commented [A19]: Subscript formatting preserved, unlike in final released version of bulletin.

Commented [A20]: Subscript formatting of footnotes preserved, unlike in final released version of bulletin.

Commented [A21]: Remove extra space between words "after" and "considering".

Commented [A22]: Removing the space between the beginning of this page and the first section to keep proposed sections 2.6 and revised section 2.7 and section 2.8 all on one page.

2.6. Frequency Droop Settings

Commented [A23]: Section added to provide missing guidance for required smart inverter settings for Frequency Droop as required to be activated per Table 1-2.

Smart Inverters shall be set to Frequency Droop (Freq-Watt) Settings in Table 2-8.

Table 2-8- Frequency Droop Settings

Frequency Droop Parameters	Default Setting	Range of allowable settings	
		Category I / Category II	Category III
db_{OF}, db_{UF}	0.250	0.017 – 1.0	0.017 – 1.0
k_{OF}, k_{UF}	0.05	0.03 – 0.05	0.02 – 0.05
Open Loop Response Time	0.5 s	1 seconds – 10 seconds	0.2 seconds – 10 seconds

Commented [A24]: Proposed revision to increase the deadband setting to 0.250 (250 mHz)

Commented [A25]: Proposed revision that this response time needs to be faster. Should be an order of magnitude shorter (e.g. 0.5 seconds). This is consistent with the required OLRT for HECO SRD V2.0.

~~2.6.~~2.7. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-9.

Table 2-9- Enter Service Settings

Enter Service Criteria		Default Setting	Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
Applicable voltage within range	Minimum value	≥ 0.88 p.u.	0.88 p.u. to 0.95 p.u.
	Maximum value	≤ ~~1.06~~1.10 p.u	1.05 p.u. to ~~1.06~~1.10 p.u.
Frequency within range	Minimum value	≥ ~~59.5~~59.0 Hz	59 Hz to 59.9 Hz
	Maximum value	≤ ~~60.1~~60.5 Hz	60.1 Hz to 61.0 Hz
Enter Service Delay		~~300~~ 15 s	0 seconds to 600 seconds
Enter Service Randomized Delay		N/A	1 second to 1000 seconds
Enter Service Ramp Rate		50 s	1 second to 1000 seconds

Commented [A26]: Formatting of chart changed for consistency with other tables in bulletin.

Commented [A27]: Table header fill color corrected for consistency with other tables in bulletin.

Commented [A28]: Proposed revision to increase the voltage setting due to issues with grid regulation.

Commented [A29]: Proposed revision to reduce the value to 59.0 Hz. Setting would match required parameter value in CA Rule 21 post 08-29-2023.

Commented [A30]: Proposed revision to increase setting to 60.5 Hz due to regulation variance from the Grid. Setting would match required value in CA Rule 21.

Commented [A31]: Proposed revision per Enphase comment to reduce setting to 15 seconds. Setting would match required value in CA Rule 21

~~2.7.~~2.8. Ramp Rate Settings

The following is the ramp-rate requirement during normal ~~and reconnection~~ operation of Smart Inverters:

- Normal ramp-up rate (Optional): For transitions between energy output levels over the normal course of operation, the default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.
- ~~Connect/Reconnect Ramp up rate: Upon starting power into the grid, following a period of inactivity or a disconnection, the inverter shall wait for 300 seconds before reconnecting and shall be able to control its rate of increase of power from 1 to 100% maximum current per second. The default value is 2% of maximum current output per second. The maximum active power step during restoring output is 20%~~

Commented [A32]: See comment below. Removal of connect/reconnect ramp rate subsection is proposed due to it being redundant makes this language no longer applicable to the section.

Commented [A33]: This is Enter Service Ramp Rate and is therefore redundant.

Attachment 2 – Proposed New Settings, showing “comments” (without “track changes”)

Table of Contents

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List of Tables

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1. Required Smart Inverter Functions

Smart Inverters must be (a) UL 1741 SB listed, (b) set to the default setting provided in this document, and (c) perform the default functions, provided in this document, "Smart Inverter Settings Sheets".

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1.1. Communication Requirements

Table 1-1~~Table 1-1~~ lists the eligible communication protocols for Smart Inverters connected to the distribution system. Smart Inverters connecting to the distribution system shall be capable of supporting at least one of these protocols.

Table 1-1- List of eligible communication protocols

Protocol	Transport	Physical Interface/Layer
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IEEE 1815 (DNP3)	TCP/IP	Ethernet
SunSpec Modbus	TCP/IP	Ethernet
	N/A	RS-485

1.2. Smart Inverter Functions and Control Modes

Table 1-1~~Table 1-1~~ lists functions and control modes that must be supported by Smart Inverters as well as the default status of each function and control mode.

Commented [A4]: Corrects improper table reference (Table 1-1 to Table 1-2)

Table 1-2- Smart Inverter Control Modes

Applicable to Retail Customers Interconnected			
Function/ Control Mode of Operation	**Required/Optional**	**Description**	**Default Activation Status**
Anti-Islanding	Required	Refers to the ability to detect loss of utility source and cease to energize	Activated
Constant power factor	Required	Refers to Power Factor set to a fixed value.	Deactivated
Active Power – Reactive Power	Required	Refers to the control of real power output as a function of reactive power	Deactivated
Constant Reactive Power	Required	Refers to Reactive Power set to a fixed value	Deactivated
Voltage Ride through	Required	Refers to the ability of Smart Inverter to ride through a certain range of voltages before tripping off	Activated
Frequency Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	Activated
Voltage – Reactive Power (Volt/Var)	Required	Refers to control of reactive power output as a function of voltage	Activated
Voltage – Active Power (Volt/Watt)	Required	Refers to control of real power output as a function of voltage	Deactivated*
Frequency Droop (Frequency – Watt)	Required	Refers to control of real power as a function of frequency	Activated
Enter Service	Required	Refers to the ability of smart inverters to begin operation with an energized utility source.	Activated
Normal Ramp-up Rates	Optional	Refers to ability to transition between energy output levels over the normal course of operation	Activated, if available
Connect/Reconnect Ramp-up rate	Required	Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power	Activated

* Not earlier than June 30, 2026, the Energy Bureau will consider approving, through Resolution, the activation of this function after considering: (i) recommendations from LUMA and Working Group regarding system performance, (ii) implementation of adequate reporting and tracking requirements for customer curtailment, and (iii) LUMA has developed an effective plan to manage distribution voltage, that relies on Volt-Watt functionality as a last resort mechanism to temporarily correct voltage issues.

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Commented [A10]: Postpones until at least June 2026 consideration of Volt-Watt activation.

2. Smart Inverter Function and Control Mode Settings

This section lists the required settings for Smart Inverter functions and control modes.

2.1. Anti-Islanding

Smart Inverters shall detect the unintentional island and trip as specified in Table 2-1.

Table 2-1- Responses to Islanding and Open Phase Conditions - ACTIVATED

Applicable to Retail Customers Interconnected	
Condition	**Maximum Trip Time (s)**
Islanding/Open Phase	2

2.2. Response to Abnormal Voltage

2.2.1. Voltage Trip Settings

Smart Inverters shall meet the abnormal voltage response requirements, as specified in Table 2-2.

Table 2-2- Smart Inverter Response to Abnormal Voltage

Voltage Trip Settings	Default Voltage (pu)	Adjustable Range for Voltage (pu)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Voltage 2 (OV2)	V ≥ 1.2	1.2	0.16	Fixed at 0.16
Over Voltage 1 (OV1)	V ≥ 1.1	1.1 - 1.2	13	1 - 13
Under Voltage 1 (UV1)	V ≤ 0.88	0 - 0.88	21	11 - 50
Under Voltage 2 (UV2)	V ≤ 0.5	0 - 0.5	2	2 - 21

2.2.2. Voltage Ride-Through

Smart Inverters shall meet the Low/High Voltage Ride-Through requirements, as specified in Table 2-3, which match the required response for Abnormal Operating Category III.

Table 2-3- Low/High Voltage Ride-Through Minimum Requirement – ACTIVATED

Voltage Range	Voltage Range (pu)	Operating Mode/Response	Maximum Ride Through Time (s) (design criteria)	Minimum Ride Through Time (s) (Design Criteria)
High Voltage 2	V ≥ 1.2	Cease to Energize	0.16	N/A
High Voltage 1	1.1 < V ≤ 1.2	Momentary Cessation	0.083	12
Near Normal Voltage	0.88 ≤ V ≤ 1.1	Continuous Operation	N/A	Infinite
Low Voltage 1	0.7 ≤ V < 0.88	Mandatory Operation	N/A	20
Low Voltage 2	0.5 ≤ V < 0.7	Mandatory Operation	N/A	10
Low Voltage 3	V < 0.5	Momentary Cessation	0.083	1

Commented [A11]: A space added to address formatting to be consistent.

Commented [A12]: Addresses an symbol error (from less-than-or equal symbol to less-than symbol) in table to make it compliant with IEEE 1547-2018 Table 16.

Commented [A13]: Addresses an symbol error (from less-than-or equal symbol to less-than symbol) in table to make it compliant with IEEE 1547-2018 Table 16.

2.3. Response to Abnormal Frequency

2.3.1. Frequency Trip Settings

Smart Inverters shall meet the abnormal frequency response requirements, as specified in Table 2-4.

Table 2-4- Smart Inverter Response to Abnormal Frequency

Frequency Trip Settings	Default Frequency (Hz)	Adjustable Range for Frequency(Hz)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Frequency 2	f ≥ 62	61.8 - 66	0.16	0.16 - 1000
Over Frequency 1	f ≥ 61.2	61.2 - 66	300	21 - 1000
Under Frequency 1	f ≤ 58.5	50 - 58.8	300	21 - 1000
Under Frequency 2	f ≤ 56.5	50 - 57	0.16	0.16 - 1000

2.3.2. Frequency Ride-Through

Smart Inverters shall meet the Low/High Frequency Ride-Through requirements, as specified in Table 2-5, which match the required response for Abnormal Operating Categories I, II, and III.

Table 2-5- Low/High Frequency Ride-Through Minimum Requirement – ACTIVATED

Frequency Ride-Through Settings	Frequency Range (Hz)	Operating Mode	Minimum Ride Through Time (s)
High Frequency 2	f > 62	N/A	N/A
High Frequency 1	61.2 < f ≤ 62	Mandatory Operation	299
Near Normal Frequency	58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite
Low Frequency 1	57 ≤ f < 58.8	Mandatory Operation	299
Low Frequency 2	f < 57	N/A	N/A

Commented [A14]: Addresses a symbol error in table to make it compliant with IEEE 1547-2018 table 19 (replace greater-than-or-equal-to symbol with greater-than symbol).

Commented [A15]: Addresses a symbol error in table to make it compliant with IEEE 1547-2018 table 19 (replace less-than-or-equal-to symbol with less-than symbol).

2.4. Voltage-Reactive Power Control Mode Settings

An example Volt-Var characteristic is shown in Figure 2-1~~Figure 2-1~~. The voltage-reactive power characteristic shall be configured in accordance with the default parameter values specified in Table 2-6~~Table 2-6~~.

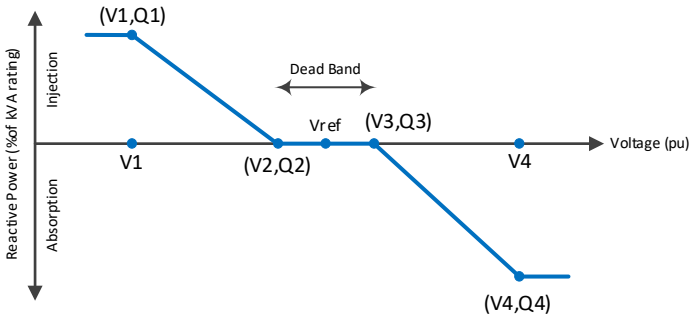

Figure 2-1. Example Volt-Var characteristic

Table 2-6- Volt-Var Settings – ACTIVATED

Volt-Var Parameters	Definitions	Default Values (% of nominal rating)	Allowable Range	
			Minimum	Maximum
Vref	Dead band center	VN	95% VN	105% VN
V2	Dead band lower voltage limit	98% VN	Vref – 3%VN	Vref
Q2	Reactive power injection or absorption at voltage V2	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V3	Dead band upper voltage limit	105% VN	Vref	Vref + 3%VN
Q3	Reactive power injection or absorption at voltage V3	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V1	Voltage at which DER shall inject Q1 reactive power	92% VN	Vref – 18%VN	V2 – 2%VN
Q1(1)	Reactive power injection at voltage V1	44%	0	maximum reactive power capability, injection
V4	Voltage at which DER shall absorb Q4 reactive power	108% VN	V3 + 2%VN	Vref + 18%VN
Q4(1)	Reactive power absorption at voltage V4	44%	maximum reactive power capability, absorption	0
Open loop response time	Time to 90% of the reactive power change in response to the change in voltage	5 sec	1 sec	90 sec

(1) This requires that the Smart Inverter operates with a reactive power priority and generate/absorb reactive power to the ranges specified in this table irrespective of active power production.

2.5. Voltage-Active Power Control Mode Settings

Two examples of these characteristics are shown in Figure 2-2~~Figure 2-2~~. The characteristic shall be configured in accordance with the default parameter values specified in Table 2-7.

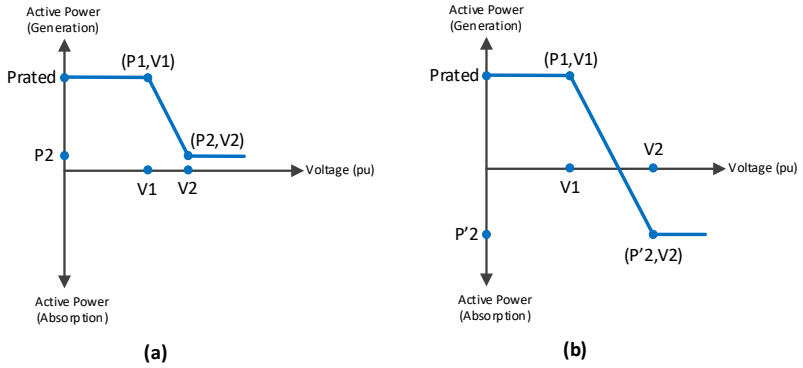

Figure 2-2. Example Volt-Watt characteristics

Table 2-7- Volt-Watt Settings –[3] DEACTIVATED

Voltage-active power parameters	Default Settings	Ranges of allowable settings	
		Minimum	Maximum
V1	106% VN	105% VN	109% VN
P1	P_{RATED}	NA	NA
V2	110% VN	V1 + 1% VN	110% VN
P2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{RATED} or P_{MIN}[1]	P_{MIN}	P_{RATED}
P'2 (applicable to DER that can generate and absorb active power)	0	0	P'_{RATED}[2]
Open-loop response time	10 sec	0.5 sec	60 sec

[1] P_{MIN} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.).
[2] P'_{RATED} is the maximum amount of active power that can be absorbed by the DER.
[3] Will remain Deactivated for at least 6 months. Not earlier than June 30, 2025, the Energy Bureau will consider approving through Resolution, the activation of this function after considering: (i) recommendations from LUMA and Working Group regarding system performance, (ii) implementation of adequate reporting and tracking requirements for customer curtailment, and (iii) LUMA has developed an effective plan to manage distribution voltage, that relies on Volt-Watt functionality as a last resort mechanism the temporarily correct voltage issues.

Commented [A16]: Formatting edits for use of space on page 7 keeps all Volt-Watt information on one page without compromising readability.

Commented [A17]: Given that it is not certain Volt-Watt will be required, DEACTIVATED should be the status until such time a PREB Resolution is issued and with a revision of this bulletin.

Commented [A18]: Subscript formatting preserved, unlike in final released version of bulletin.

Commented [A19]: Subscript formatting preserved, unlike in final released version of bulletin.

Commented [A20]: Subscript formatting of footnotes preserved, unlike in final released version of bulletin.

Commented [A21]: Remove extra space between words "after" and "considering".

Commented [A22]: Removing the space between the beginning of this page and the first section to keep proposed sections 2.6 and revised section 2.7 and section 2.8 all on one page.

2.6. Frequency Droop Settings

Smart Inverters shall be set to Frequency Droop (Freq-Watt) Settings in Table 2-8.

Table 2-8- Frequency Droop Settings

Frequency Droop Parameters	Default Setting	Range of allowable settings	
		Category I / Category II	Category III
db_{OF}, db_{UF}	0.250	0.017 – 1.0	0.017 – 1.0
k_{OF}, k_{UF}	0.05	0.03 – 0.05	0.02 – 0.05
Open Loop Response Time	0.5 s	1 seconds – 10 seconds	0.2 seconds – 10 seconds

2.7. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-9.

Table 2-9- Enter Service Settings

Enter Service Criteria		Default Setting	Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
Applicable voltage within range	Minimum value	≥ 0.88 p.u.	0.88 p.u. to 0.95 p.u.
	Maximum value	≤ 1.10 p.u	1.05 p.u. to 1.10 p.u.
Frequency within range	Minimum value	≥ 59.0 Hz	59 Hz to 59.9 Hz
	Maximum value	≤ 60.5 Hz	60.1 Hz to 61.0 Hz
Enter Service Delay		15 s	0 seconds to 600 seconds
Enter Service Randomized Delay		N/A	1 second to 1000 seconds
Enter Service Ramp Rate		50 s	1 second to 1000 seconds

2.8. Ramp Rate Settings

The following is the ramp-rate requirement during normal operation of Smart Inverters:

- Normal ramp-up rate (Optional): For transitions between energy output levels over the normal course of operation, the default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.

Commented [A23]: Section added to provide missing guidance for required smart inverter settings for Frequency Droop as required to be activated per Table 1-2.

Commented [A24]: Proposed revision to increase the deadband setting to 0.250 (250 mHz)

Commented [A25]: Proposed revision that this response time needs to be faster. Should be an order of magnitude shorter (e.g. 0.5 seconds). This is consistent with the required OLRT for HECO SRD V2.0.

Commented [A26]: Formatting of chart changed for consistency with other tables in bulletin.

Commented [A27]: Table header fill color corrected for consistency with other tables in bulletin.

Commented [A28]: Proposed revision to increase the voltage setting due to issues with grid regulation.

Commented [A29]: Proposed revision to reduce the value to 59.0 Hz. Setting would match required parameter value in CA Rule 21 post 08-29-2023.

Commented [A30]: Proposed revision to increase setting to 60.5 Hz due to regulation variance from the Grid. Setting would match required value in CA Rule 21.

Commented [A31]: Proposed revision per Enphase comment to reduce setting to 15 seconds. Setting would match required value in CA Rule 21

Commented [A32]: See comment below. Removal of connect/reconnect ramp rate subsection is proposed due to it being redundant makes this language no longer applicable to the section.

Commented [A33]: This is Enter Service Ramp Rate and is therefore redundant.

SESA SOLAR AND ENERGY STORAGE ASSOCIATION OF PUERTO RICO

Attachment 3 – Full, Clean, Proposed New Smart Inverter Settings for Puerto Rico

Table of Contents

List of Tables

List of Figures

1. Required Smart Inverter Functions

Smart Inverters must be (a) UL 1741 SB listed, (b) set to the default setting provided in this document, and (c) perform the default functions, provided in this document, "Smart Inverter Settings Sheets".

Customers must comply with the requirements set forth in this "Smart Inverter Settings Sheets" except where alternative site-specific Smart Invert settings and function statuses are defined in the interconnection agreement as a result of a detailed interconnection study. Any alternative settings and function statuses defined in the interconnection agreement will take precedence and supersede the default settings and function statuses provided in this document. Notwithstanding the following provisions of this "Smart Inverter Settings Sheets", customer's Smart Inverter(s) shall conform with the requirements and functions required pursuant to interconnection agreement.

1.1. Communication Requirements

Table 1-1~~Table 1-1~~ lists the eligible communication protocols for Smart Inverters connected to the distribution system. Smart Inverters connecting to the distribution system shall be capable of supporting at least one of these protocols.

Table 1-1- List of eligible communication protocols

Protocol	Transport	Physical Interface/Layer
IEEE 2030.5 (SEP 2.0)	TCP/IP	Ethernet
IEEE 1815 (DNP3)	TCP/IP	Ethernet
SunSpec Modbus	TCP/IP	Ethernet
	N/A	RS-485

1.2. Smart Inverter Functions and Control Modes

Table 1-1~~Table 1-1~~ lists functions and control modes that must be supported by Smart Inverters as well as the default status of each function and control mode.

Table 1-2- Smart Inverter Control Modes

Applicable to Retail Customers Interconnected			
Function/ Control Mode of Operation	**Required/Optional**	**Description**	**Default Activation Status**
Anti-Islanding	Required	Refers to the ability to detect loss of utility source and cease to energize	Activated
Constant power factor	Required	Refers to Power Factor set to a fixed value.	Deactivated
Active Power – Reactive Power	Required	Refers to the control of real power output as a function of reactive power	Deactivated
Constant Reactive Power	Required	Refers to Reactive Power set to a fixed value	Deactivated
Voltage Ride through	Required	Refers to the ability of Smart Inverter to ride through a certain range of voltages before tripping off	Activated
Frequency Ride through	Required	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	Activated
Voltage – Reactive Power (Volt/Var)	Required	Refers to control of reactive power output as a function of voltage	Activated
Voltage – Active Power (Volt/Watt)	Required	Refers to control of real power output as a function of voltage	Deactivated*
Frequency Droop (Frequency – Watt)	Required	Refers to control of real power as a function of frequency	Activated
Enter Service	Required	Refers to the ability of smart inverters to begin operation with an energized utility source.	Activated
Normal Ramp-up Rates	Optional	Refers to ability to transition between energy output levels over the normal course of operation	Activated, if available
Connect/Reconnect Ramp-up rate	Required	Refers to ability to have an adjustable entry service ramp rate when a DER restores output of active power	Activated

* Not earlier than June 30, 2026, the Energy Bureau will consider approving, through Resolution, the activation of this function after considering: (i) recommendations from LUMA and Working Group regarding system performance, (ii) implementation of adequate reporting and tracking requirements for customer curtailment, and (iii) LUMA has developed an effective plan to manage distribution voltage, that relies on Volt-Watt functionality as a last resort mechanism to temporarily correct voltage issues.

2. Smart Inverter Function and Control Mode Settings

This section lists the required settings for Smart Inverter functions and control modes.

2.1. Anti-Islanding

Smart Inverters shall detect the unintentional island and trip as specified in Table 2-1.

Table 2-1- Responses to Islanding and Open Phase Conditions - ACTIVATED

Applicable to Retail Customers Interconnected	
Condition	**Maximum Trip Time (s)**
Islanding/Open Phase	2

2.2. Response to Abnormal Voltage

2.2.1. Voltage Trip Settings

Smart Inverters shall meet the abnormal voltage response requirements, as specified in Table 2-2.

Table 2-2- Smart Inverter Response to Abnormal Voltage

Voltage Trip Settings	Default Voltage (pu)	Adjustable Range for Voltage (pu)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Voltage 2 (OV2)	V ≥ 1.2	1.2	0.16	Fixed at 0.16
Over Voltage 1 (OV1)	V ≥ 1.1	1.1 - 1.2	13	1 - 13
Under Voltage 1 (UV1)	V ≤ 0.88	0 - 0.88	21	11 - 50
Under Voltage 2 (UV2)	V ≤ 0.5	0 - 0.5	2	2 - 21

2.2.2. Voltage Ride-Through

Smart Inverters shall meet the Low/High Voltage Ride-Through requirements, as specified in Table 2-3, which match the required response for Abnormal Operating Category III.

Table 2-3- Low/High Voltage Ride-Through Minimum Requirement – ACTIVATED

Voltage Range	Voltage Range (pu)	Operating Mode/Response	Maximum Ride Through Time (s) (design criteria)	Minimum Ride Through Time (s) (Design Criteria)
High Voltage 2	V ≥ 1.2	Cease to Energize	0.16	N/A
High Voltage 1	1.1 < V ≤ 1.2	Momentary Cessation	0.083	12
Near Normal Voltage	0.88 ≤ V ≤ 1.1	Continuous Operation	N/A	Infinite
Low Voltage 1	0.7 ≤ V < 0.88	Mandatory Operation	N/A	20
Low Voltage 2	0.5 ≤ V < 0.7	Mandatory Operation	N/A	10
Low Voltage 3	V < 0.5	Momentary Cessation	0.083	1

2.3. Response to Abnormal Frequency

2.3.1. Frequency Trip Settings

Smart Inverters shall meet the abnormal frequency response requirements, as specified in Table 2-4.

Table 2-4- Smart Inverter Response to Abnormal Frequency

Frequency Trip Settings	Default Frequency (Hz)	Adjustable Range for Frequency(Hz)	Default Trip/Clearing Time (s)	Adjustable Range for Trip Time (s)
Over Frequency 2	f ≥ 62	61.8 - 66	0.16	0.16 - 1000
Over Frequency 1	f ≥ 61.2	61.2 - 66	300	21 - 1000
Under Frequency 1	f ≤ 58.5	50 - 58.8	300	21 - 1000
Under Frequency 2	f ≤ 56.5	50 - 57	0.16	0.16 - 1000

2.3.2. Frequency Ride-Through

Smart Inverters shall meet the Low/High Frequency Ride-Through requirements, as specified in Table 2-5, which match the required response for Abnormal Operating Categories I, II, and III.

Table 2-5- Low/High Frequency Ride-Through Minimum Requirement – ACTIVATED

Frequency Ride-Through Settings	Frequency Range (Hz)	Operating Mode	Minimum Ride Through Time (s)
High Frequency 2	f > 62	N/A	N/A
High Frequency 1	61.2 < f ≤ 62	Mandatory Operation	299
Near Normal Frequency	58.8 ≤ f ≤ 61.2	Continuous Operation	Infinite
Low Frequency 1	57 ≤ f < 58.8	Mandatory Operation	299
Low Frequency 2	f < 57	N/A	N/A

2.4. Voltage-Reactive Power Control Mode Settings

An example Volt-Var characteristic is shown in Figure 2-1~~Figure 2-1~~. The voltage-reactive power characteristic shall be configured in accordance with the default parameter values specified in Table 2-6~~Table 2-6~~.

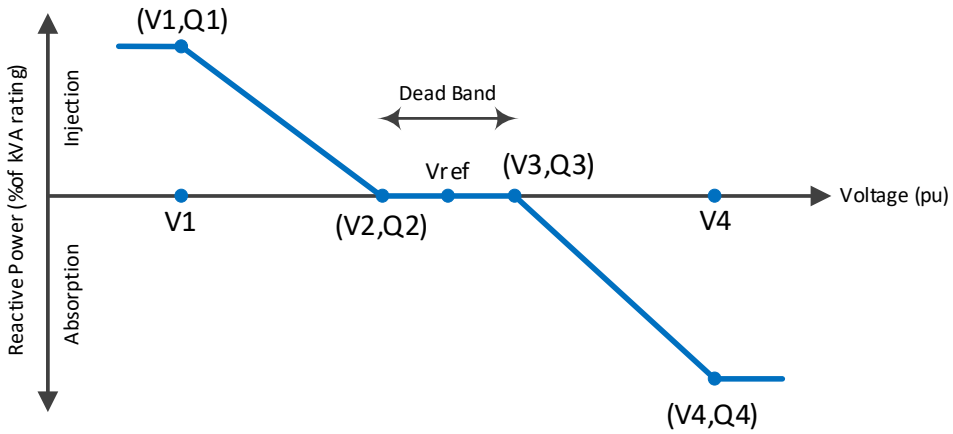

Figure 2-1. Example Volt-Var characteristic

Table 2-6- Volt-Var Settings – ACTIVATED

Volt-Var Parameters	Definitions	Default Values (% of nominal rating)	Allowable Range	
			Minimum	Maximum
Vref	Dead band center	VN	95% VN	105% VN
V2	Dead band lower voltage limit	98% VN	Vref – 3%VN	Vref
Q2	Reactive power injection or absorption at voltage V2	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V3	Dead band upper voltage limit	105% VN	Vref	Vref + 3%VN
Q3	Reactive power injection or absorption at voltage V3	0	maximum reactive power capability, absorption	maximum reactive power capability, injection
V1	Voltage at which DER shall inject Q1 reactive power	92% VN	Vref – 18%VN	V2 – 2%VN
Q1(1)	Reactive power injection at voltage V1	44%	0	maximum reactive power capability, injection
V4	Voltage at which DER shall absorb Q4 reactive power	108% VN	V3 + 2%VN	Vref + 18%VN
Q4(1)	Reactive power absorption at voltage V4	44%	maximum reactive power capability, absorption	0
Open loop response time	Time to 90% of the reactive power change in response to the change in voltage	5 sec	1 sec	90 sec

(1) This requires that the Smart Inverter operates with a reactive power priority and generate/absorb reactive power to the ranges specified in this table irrespective of active power production.

2.5. Voltage-Active Power Control Mode Settings

Two examples of these characteristics are shown in Figure 2-2~~Figure 2-2~~. The characteristic shall be configured in accordance with the default parameter values specified in Table 2-7.

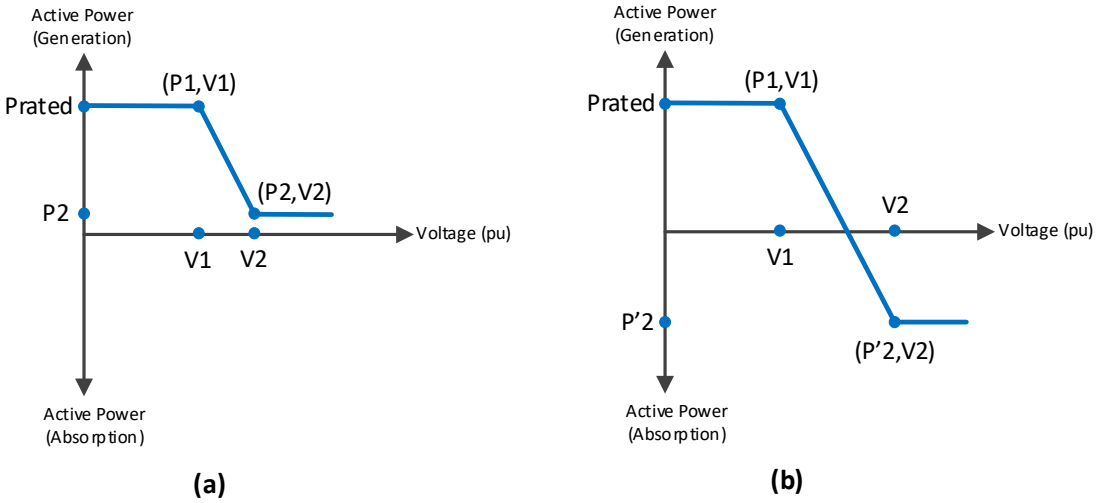

Figure 2-2. Example Volt-Watt characteristics

Table 2-7- Volt-Watt Settings –(3) DEACTIVATED

Voltage-active power parameters	Default Settings	Ranges of allowable settings	
		Minimum	Maximum
V1	106% VN	105% VN	109% VN
P1	P_{RATED}	NA	NA
V2	110% VN	V1 + 1% VN	110% VN
P2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{RATED} or P_{MIN}(1)	P_{MIN}	P_{RATED}
P'2 (applicable to DER that can generate and absorb active power)	0	0	P'_{RATED}(2)
Open-loop response time	10 sec	0.5 sec	60 sec

(1) P_{MIN} is the minimum active power output in p.u. of the DER rating (i.e., 1.0 p.u.).
(2) P'_{RATED} is the maximum amount of active power that can be absorbed by the DER.
(3) Will remain Deactivated for at least 6 months. Not earlier than June 30, 2025, the Energy Bureau will consider approving through Resolution, the activation of this function after considering: (i) recommendations from LUMA and Working Group regarding system performance, (ii) implementation of adequate reporting and tracking requirements for customer curtailment, and (iii) LUMA has developed an effective plan to manage distribution voltage, that relies on Volt-Watt functionality as a last resort mechanism the temporarily correct voltage issues.

2.6. Frequency Droop Settings

Smart Inverters shall be set to Frequency Droop (Freq-Watt) Settings in Table 2-8.

Table 2-8- Frequency Droop Settings

Frequency Droop Parameters	Default Setting	Range of allowable settings	
		Category I / Category II	Category III
db_{OF}, db_{UF}	0.250	0.017 – 1.0	0.017 – 1.0
k_{OF}, k_{UF}	0.05	0.03 – 0.05	0.02 – 0.05
Open Loop Response Time	0.5 s	1 seconds – 10 seconds	0.2 seconds – 10 seconds

2.7. Enter Service Settings

Smart Inverters shall be set to the Enter Service Settings in Table 2-9.

Table 2-9- Enter Service Settings

Enter Service Criteria		Default Setting	Ranges of allowable settings
Permit Service		Enabled	Enabled/Disabled
Applicable voltage within range	Minimum value	≥ 0.88 p.u.	0.88 p.u. to 0.95 p.u.
	Maximum value	≤ 1.10 p.u	1.05 p.u. to 1.10 p.u.
Frequency within range	Minimum value	≥ 59.0 Hz	59 Hz to 59.9 Hz
	Maximum value	≤ 60.5 Hz	60.1 Hz to 61.0 Hz
Enter Service Delay		15 s	0 seconds to 600 seconds
Enter Service Randomized Delay		N/A	1 second to 1000 seconds
Enter Service Ramp Rate		50 s	1 second to 1000 seconds

2.8. Ramp Rate Settings

The following is the ramp-rate requirement during normal operation of Smart Inverters:

- Normal ramp-up rate (Optional): For transitions between energy output levels over the normal course of operation, the default value is 100% of maximum current output per second with a range of adjustment between 1% to 100%.